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Impact Of Design Changes on Time and Cost Control of The Namrole – Leksula I Road Project

Muhammad Ikhsanudin[1], Inge Anggitasari[2], Susilowati[3], Monica Dewi[4]

[1,2,3,4)]Program Studi Teknik Sipil, Universitas Kahuripan Kediri, Indonesia
Coresponding Author Email : muhammad.ikhsanudin@students.kahuripan.ac.id

This study investigates the impact of design changes on time and cost control in the Namrole-Leksula I road project in Maluku Province. The research aims to identify key factors influencing design modifications and to develop strategies for managing their effects on project scheduling and budgeting. A quantitative-descriptive approach was employed, utilizing direct data collection, field technical surveys, and stakeholder interviews. The population comprises project execution personnel and government officials, with purposive sampling of 20 experts. Data were analyzed using Critical Path Method (CPM) tools and volume comparison techniques for work items. The results indicate that unstable subgrade soil, road width variability, and damaged structures significantly affected work volume and necessitated contract amendments without changing total project duration or budget. The study concludes that integrating CPM with field assessments provides effective management for mitigating risks from mid-project design changes while maintaining quality and timeline compliance. Future research should explore broader contexts and advanced monitoring tools.Abstract

Keywords *: Construction Management, Design Change, Project Cost Control, Project Scheduling, Road Construction*

INTRODUCTION

The construction project for the Namrole-Leksula I road in Maluku Province represents a significant infrastructural development aimed at improving accessibility from formerly limited sea and footpath routes. Such infrastructure initiatives typically involve complex management of time, cost, and quality, all of which are highly sensitive to design modifications during implementation. Design changes often emerge due to site-specific constraints or adjustments requested by project owners, which inevitably impact project schedules and budgets (Efendi, 2024; Agsarini, 2015). These phenomena underscore the inherent challenges in maintaining control over project parameters while adapting to evolving conditions in civil construction projects (Ibbs, 1997; Sun & Meng, 2009).

The Namrole-Leksula I road project is currently at 70% completion but faces critical issues due to required route alignment changes. Such alterations have introduced significant impacts on project cost management and schedule adherence, precipitating a need for detailed investigation of the underlying causes and effects of these design changes. Previous studies have identified both internal (e.g., project team coordination, technical planning) and external factors (e.g., environmental conditions, regulatory constraints) as primary contributors to deviations in project timelines and cost overruns (Agsarini, 2015; Memon et al., 2012). Furthermore, the dynamic between design change impacts and project performance metrics such as cost efficiency, schedule compliance, and quality outcomes is complex and necessitates comprehensive analysis specifically tailored to this context (Efendi, 2024; Trisnawati, 2023).

Central research problems address the motivations behind design modifications, the procedural steps for assessing their influence on schedule and budget, and the resultant effects on project delivery effectiveness. This study seeks to clarify how route design changes materially alter project time and cost controls while sustaining quality standards. Such inquiry is particularly urgent given the constrained timeline and budget environment of the Namrole-Leksula I project, providing critical insights for mitigating risks associated with mid-project design revisions in similar infrastructure developments (Efendi, 2024; Agsarini, 2015). The study is novel in its application of Critical Path Method (CPM) analysis combined with field technical assessments to quantify and manage design change impacts in this unique geographical and logistical setting (Malawauw et al., 2025; Efendi, 2024).

The aim of this research is to systematically identify key factors influencing design changes and their repercussions on time and cost control, alongside developing practical strategies to manage these effects for the Namrole-Leksula I road construction project. The investigation integrates quantitative schedule analysis with stakeholder feedback to propose a balanced approach that preserves project viability despite necessary adjustments. This approach not only contributes empirical evidence to the field of construction project management but also offers actionable guidance to practitioners confronting the realities of design evolution mid-execution (Efendi, 2024; Malawauw et al., 2025).

RESEARCH METHODS

This study employs a quantitative-descriptive research design focusing on evaluating the effects of design modifications on project time and cost control. The research is conducted through direct data collection and field analysis, aligning with the Critical Path Method (CPM) framework, which is appropriate for investigating schedule and budget impacts in construction projects (Efendi, 2024; Agsarini, 2015). The methodology integrates both qualitative and quantitative approaches as supported by Creswell (2022), enabling comprehensive insight into the project dynamics after design changes.

Data were collected using structured instruments including field observations, technical surveys, and stakeholder discussions to capture variables influencing project performance such as labor input, material usage, environmental conditions, and project management practices (Sugiyono, 2023; Sudaryono, 2024). Analysis was carried out using CPM tools and comparative evaluation of volume changes in work items to assess shifts in schedule and budget control (Malawauw et al., 2025; Emzir, 2022). The use of technical field assessments complements schedule simulations to provide a robust examination of design change effects.

The population for this study consists of all project execution personnel and government officials directly involved in the Namrole-Leksula I road construction project in Buru Selatan, Maluku Province. A purposive sampling method was applied, targeting 20 expert respondents who are actively engaged with project implementation and have direct experience with project modifications and management challenges (Efendi, 2024; Sugiyono, 2023). This focused sampling ensures relevance and depth in the perspectives gathered.

The research procedure unfolded over several stages, beginning with preparation and mobilization between August 2024 and May 2025, followed by systematic data collection from September to October. Subsequent steps involved data processing, proposal completion, and seminars from October to January, with thesis writing, hypothesis testing, and final examinations conducted between January and May 2025 (Efendi, 2024; Sudaryono, 2024). This structured timeline supports rigorous validation and reflection consistent with action research cycles as described by Creswell (2022).

RESULTS AND DISCUSSION

General Data

1. Road Segment Length : 17.00 Kilometers
2. Road Segment Width : 10.70 meters
3. Pavement Width : 5.50 meters
4. Asphalt Surface Type : Laston Wearing Course (HRS – WC)
5. Implementation Period : 461 Calendar Days
6. Maintenance Period : 730 Calendar Days
7. Maintenance End Date : May 6, 2026

Figure 2. Project Location

Current Conditions

Field inspections have been carried out on the condition of all existing construction components, including existing culvert constructions, the condition of the river drainage area, and the condition of the access road.

- **Field Inspection**

  An inspection has been carried out at the planned work location with the following description:
  1.Inspection of the existing road conditions.
  2. Inspection of the need for supplementary buildings.
  3. Inspection of existing Cross Drain structures.

  After conducting field inspections and observations, several issues were identified as follows:
  1. The width of the existing road ranges from 5 to 8 meters.
  2. There are several locations where the road surface consists of gravel, dry soil, and muddy soil.
  3. There are hills with soil and rock surfaces.
  4. There are very steep lower slopes.

5. The curve radius is small and changes direction.
6. The road gradient is more than 17% in several locations.
7. Some existing Cross Drain structures are damaged, and there are two existing bridges.

- **Engineering Planning**

  An inspection has been carried out at the planned work location with the following details:
  1. Inspection of the condition of the existing road.
  2. Inspection of the requirements for supporting buildings.
  3. Inspection of the existing Cross Drain structures.

  After the inspection and observation in the field, several issues were found as follows:
  1. The width of the existing road is between 5 – 8 meters.
  2. There are several locations where the road surface is gravel, dry soil, and muddy soil.
  3. There are hills with soil and rock surfaces.
  4. There are very steep lower slopes.
  5. Small and reversing curves.
  6. Road slopes exceed 17% in some locations.
  7. Several existing cross drain structures are in damaged condition, and there are 2 existing bridge points.

- **Engineering Planning**

  Typical I: In the planned road area without an upper slope and without a lower slope, with side channels on the left and right, the road dimensions are as follows: Pavement width = 5.5 m, shoulder = 1 m, rounding = 1 m, left and right channels = 1.2 m x 2 sides, safety barrier between the channel and the slope base = 1 m, and safety barrier between the shoulder and the edge of the lower slope = 1 m.

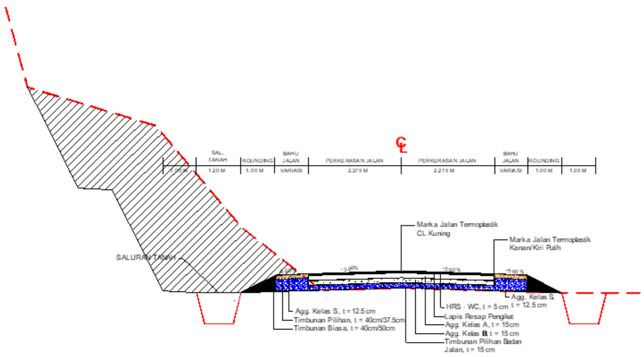

Figure 3. Typical Initial Design

Type II In the planned road area without an upper slope and without a lower slope, there are side channels on the left and right, the road dimensions are as follows: Pavement width = 5.5

m, road shoulder = 1 m, rounding = 1 m, left and right channels = 1.2 m x 2 sides, safety threshold between the channel and the foot of the slope = 1 m, and safety threshold between the shoulder and the edge of the lower slope = 1 m.

The types of work involved in the planning include:

1. General/Preparation Work: Mobilization of personnel, equipment, materials, preparation of base camp, work barracks, warehouse, site office, laboratory, environmental testing construction safety management system, and installation of project/activity signage.
2. Drainage Work: Reinforced concrete box culverts 100 cm x 100 cm, stone masonry with mortar, and excavation for drainage and water channels.
3. Routine excavation, rock excavation, routine embankment from excavation results, selected embankment from excavation sources, and roadbed preparation are examples of earthwork and geosynthetic work.
4. Granular Pavement Work: Aggregate foundation layers Class A, Class B, and Class S each approximately 15 cm, 15 cm, and 12.5 cm thick.
5. Bridge deck paved with a 5 cm thick layer of Asphalt Emulsion/Tack Coat and Wearing Course Asphalt Concrete (HRS-WC).
6. Structural Work: Gabions with galvanized wire, stone masonry, and concrete fc' 15 Mpa (shoulder rips) 10 cm thick.
7. Thermoplastic road markings, guardrails, signposts, kilometer markers, and single road signs with technical-grade reflectors are among the daily tasks and other duties.

Planning Revision

- **Field Technical Study Results**

  Based on the field technical study conducted during the mobilization period, several issues were found as follows:

  1. Ordinary excavation work with a width of 5 - 8 m was carried out simultaneously during the field technical study. The excavation material consists of muddy soil and clay soil.
  2. According to the plan drawings, there is no selected fill on the road body as a capping layer.
  3. When carrying out the work as mentioned in point 1 above, there is subgrade soil with very low bearing capacity (muddy) at a depth of 2.00 m.
  4. There are differences in the volume of work between the initial contract and the field technical study results, for the types of work including:
     a. Excavation for Drainage Ditches and Water Channels.
     b. Stone Masonry with Mortar.
     c. Reinforced Concrete Box Culverts, internal dimension 100 cm x 100 cm.
     d. Ordinary Excavation.
     e. Soft Rock Excavation.
     f. Ordinary Fill from Excavation Source.
     g. Selected Fill from Excavation Source.
     h. Roadbed Preparation.
     i. Class A Aggregate Base Course.
     j. Class B Aggregate Base Course.

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k. Class S Aggregate Base Course.
l. Prime Coat Layer - Liquid Bitumen/Emulsion.
m. Wearing Course (HRS-WC).
n. Concrete, fc'15 MPa.
o. Stone Masonry.
p. Gabion with Galvanized Coated Wire.
q. Thermoplastic Road Markings.
Guard Rails.

Discussion Results

Based on the results of the technical field study, a contract amendment is proposed to meet field requirements with the following details:

1. Increase and decrease of work quantities.
2. Items of work that have been removed.
3. Addition of new work items.
   Based on the above technical study, there are changes in the design and new payment items according to the field conditions. Therefore, it is necessary to adjust the work volume in the form of additions, reductions, and eliminated work volumes with the following provisions:
   • Contract value remains unchanged (Including 10% VAT).
   • Handling length remains the same, which is 17.00 km.
4. Adjustments in work volume, whether additions or reductions, do not result in changes to the implementation time, including:
   • Implementation Time remains 461 Calendar Days
   • Maintenance Time remains 730 Calendar Days
   Thus, the results of this Technical Study discussion are made based on field surveys and evaluations, taking into account working drawings and existing field issues, to be used as a reference for preparing contract amendments.

Load Analysis

In the table, the codes highlighted in red represent the critical path, which is the path that determines the minimum project completion time, or the path with the longest duration. This path identifies the sequence of tasks that are most decisive for completing the project. If there is a delay in any tasks on the critical path, the entire project will be delayed. These tasks are coded as: B1, B2, B3, B4, B5, C1, C2, C3, D4, D6, E1, E2, E3, E4, F1, and F2. These tasks are highly dependent on the previous tasks but can also proceed simultaneously if the previous task items already have space available for the subsequent tasks, and continue until the work volume is completed.

Table 2. Critical Path of Tasks

Kode	No. Mata Pembayaran	Uraian	Satuan	Kontrak		Pekerjaan Tambah		Pekerjaan Kurang		Kajian Teknis (MC-0)		Keterangan	Perubahan Terhadap Kontrak
				Kuantitas	Bobot (%)	Kuantitas	Bobot (%)	Kuantitas	Bobot (%)	Kuantitas	Bobot (%)		(%)
	A	B	c	d	e	f	g	h	i	j	k	l	m
		DIVISI 2. DRAINASE											
A1	2.1.(1)	Galian untuk Selokan Drainase dan Saluran Air	M^3	14,670.98	0.52	2,608.14	0.096	-	-	17,279.12	0.63	Bertambah	117.78%
A2	2.2.(1)	Pasangan Batu dengan Mortar	M^3	5,500.35	9.53	-	-	19.16	0.035	5,481.19	9.88	Berkurang	99.65%
A3	2.3.(15)	Gorong-gorong Kotak Beton Bertulang, ukuran dalam 100 cm x 100 cm	M^1	330.00	0.99	-	-	244.00	0.764	86.00	0.27	Berkurang	26.06%
A4	2.3.(15)	Gorong-gorong Kotak Beton Bertulang, ukuran dalam 200 cm x 200 cm	M^1	-	-	183.00	-	-	-	183.00	-	Item Baru	
	Jumlah Harga Pekerjaan DIVISI 2 *(masuk pada Rekapitulasi Perkiraan Harga Pekerjaan)*				11.04		0.096		0.799		10.79		
		DIVISI 3. PEKERJAAN TANAH DAN GEOSINTETIK											
B1	3.1.(1)	Galian Biasa	M^3	810,740.04	24.52	-	-	249,708.14	7.86	561,031.90	17.66	Berkurang	69.20%
B2	3.1.(2)	Galian Batu Lunak	M^3	9,193.88	0.81	66,523.57	6.10	-	-	75,717.45	6.94	Bertambah	823.56%
B3	3.2.(1a)	Timbunan Biasa dari sumber galian	M^3	48,517.82	7.46	-	-	10,590.90	1.70	37,926.92	6.07	Berkurang	78.17%
B4	3.2.(2a)	Timbunan Pilihan dari sumber galian	M^3	12,056.25	1.98	4,146.90	0.71	-	-	16,203.15	2.77	Bertambah	134.40%
B5	3.3.(1)	Penyiapan Badan Jalan	M^2	145,200.00	0.92	-	-	34,700.00	0.23	110,500.00	0.73	Berkurang	76.10%
	Jumlah Harga Pekerjaan DIVISI 3 *(masuk pada Rekapitulasi Perkiraan Harga Pekerjaan)*				35.70		6.81		9.79		34.18		
		DIVISI 5. PERKERASAN BERBUTIR											
C1	5.1.(1)	Lapis Pondasi Agregat Kelas A	M^3	13,858.29	6.15	-	-	16.44	0.01	13,841.85	6.39	Berkurang	99.88%
C2	5.1.(2)	Lapis Pondasi Agregat Kelas B	M^3	13,858.29	5.14	-	-	16.44	0.01	13,841.85	5.35	Berkurang	99.88%
C3	5.1.(3)	Lapis Pondasi Agregat Kelas S	M^3	2,793.75	0.87	-	-	1,602.73	0.52	1,191.02	0.39	Berkurang	42.63%
	Jumlah Harga Pekerjaan DIVISI 5 *(masuk pada Rekapitulasi Perkiraan Harga Pekerjaan)*				12.16		-		0.54		12.12		
		DIVISI 6. PERKERASAN ASPAL											
D4	6.1 (1)	Lapis Resap Pengikat - Aspal Cair/Emulsi	Liter	73,910.88	1.59	4,526.27	0.10	-	-	78,437.15	1.75	Bertambah	106.12%
D5	6.1 (2a)	Lapis Perekat - Aspal Cair/Emulsi	Liter			320.88	-			320.88	-	Item Baru	
D6	6.3(3)	Lataston Lapis Aus (HRS-WC)	Ton	10,301.33	22.20	95.87	0.21	-	-	10,397.20	23.31	Bertambah	100.93%
D7	6.3.(8)	Bahan anti pengelupasan	Kg	2,410.51	0.18	22.43	0.00	-	-	2,432.94	0.19	Bertambah	100.93%
	Jumlah Harga Pekerjaan DIVISI 6 *(masuk pada Rekapitulasi Perkiraan Harga Pekerjaan)*				23.97		0.32		-		25.26		
		DIVISI 7. STRUKTUR											
E1	7.1 (10)	Beton , fc'10 Mpa	M^3			128.90	-	-		128.90	-	Item Baru	
E2	7.1 (8)	Beton , fc'15 Mpa	M^3	2,610.00	4.74	164.57	0.31	-	-	2,774.57	5.25	Bertambah	106.31%
E3	7.1 (8)	Beton , fc'30 Mpa	M^3			309.84	-	-	-	309.84	-	Item Baru	

E4	7.3 (4)	Baja Tulangan Sirip BJTS 420 B	Kg			44,552.94	-	-	-	44,552.94	-	Item Baru	
E5	7.6.(1)	Pondasi Cerucuk, Penyediaan dan Pemancangan	M'			920.00	-	-	-	920.00	-	Item Baru	
E6	7.9.(1)	Pasangan Batu	M^3	4,108.35	5.64	-	-	385.26	0.55	3,723.09	5.32	Berkurang	90.62%
E7	7.15.(1)	Pembongkaran Pasangan Batu	M^3			426.15	-	-	-	426.15	-	Item Baru	
E8	7.15.(2)	Pembongkaran Beton	M^3			208.48	-	-	-	208.48	-	Item Baru	
E9	7.10.(3a)	Bronjong dengan kawat yang dilapisi Galvanis	M^3	1,421.00	1.81	-	-	36.00	0.05	1,385.00	1.84	Berkurang	97.47%
		Jumlah Harga Pekerjaan DIVISI 7 *(masuk pada Rekapitulasi Perkiraan Harga Pekerjaan)*			12.20		0.32		0.60		12.42		
		DIVISI 9. PEKERJAAN HARIAN & PEKERJAAN LAIN-LAIN											
F1	9.2.(1)	Marka Jalan Termoplastik	M^2	4,845.00	1.06	133.17	0.03	-	-	4,978.17	1.14	Bertambah	102.75%
F2	9.2.(3a)	Rambu Jalan Tunggal dengan Permukaan Pemantul Engineering Grade	Buah	88.00	0.03	-	-	-	-	88.00	0.03	Tetap	100.00%
F3	9.2.(5)	Patok Pengarah	Buah	429.00	0.08	-	-	-	-	429.00	0.08	Tetap	100.00%
F4	9.2.(6a)	Patok Kilometer	Buah	17.00	0.01	-	-	-	-	17.00	0.01	Tetap	100.00%
F5	9.2.(7)	Rel Pengaman	M^1	1,455.00	2.26	94.00	0.15	-	-	1,549.00	2.51	Bertambah	106.46%
		Jumlah Harga Pekerjaan DIVISI 9 *(masuk pada Rekapitulasi Perkiraan Harga Pekerjaan)*			3.44		0.18		-		3.77		
		JUMLAH TOTAL			100.00		7.72		11.79		100.00		96.09%

Source: Data processing results, 2025

Floor Slab Moment Analysis

The Work Time Schedule (Overall Management) based on the Handling Plan for the Namrole-Leksula I Road Construction Package (P. Buru) is shown in the image below:

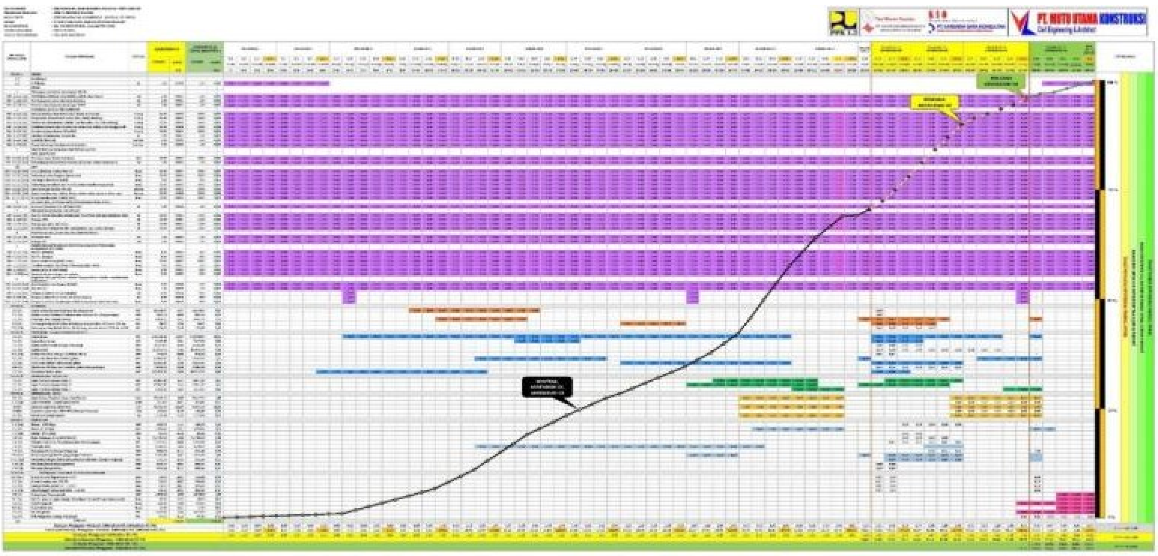

Figure 4. Work Schedule

CONCLUSION

The study reveals that design changes during the Namrole-Leksula I road project significantly impact time and cost control, primarily due to site conditions such as unstable subgrade soil, varying road widths, and damaged existing structures. These modifications led to adjustments in work volume, including excavation, drainage, and structural components, necessitating contract amendments without altering the total project duration or budget. The integration of Critical Path Method analysis and field technical evaluations proved effective in identifying critical tasks and quantifying the effects of design changes on project scheduling and budgeting. This approach enabled better management strategies to mitigate risks associated with mid-project design revisions while maintaining project quality and compliance with initial timelines.

Despite these insights, the research faces limitations in its scope, focusing solely on a single infrastructure project within a specific geographic context, which may affect the generalizability of findings. Additionally, the reliance on quantitative scheduling methods could be complemented by deeper qualitative stakeholder analysis to capture more nuanced effects of design changes. Future research should expand to diverse projects and regions to validate the findings and explore the integration of advanced project management tools such as Building Information Modeling (BIM) for real-time design change tracking. Practically, this study underscores the necessity of flexible project management frameworks that combine technical assessments with adaptive scheduling to enhance construction efficiency and cost effectiveness, providing valuable guidance for practitioners managing dynamic infrastructure projects under complex field conditions.

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